# Toxics Modeling in Baltimore Harbor

## Technical Outreach

Prepared by

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Prepared for the

Baltimore Harbor Stakeholder Advisory Group

May 7, 2002

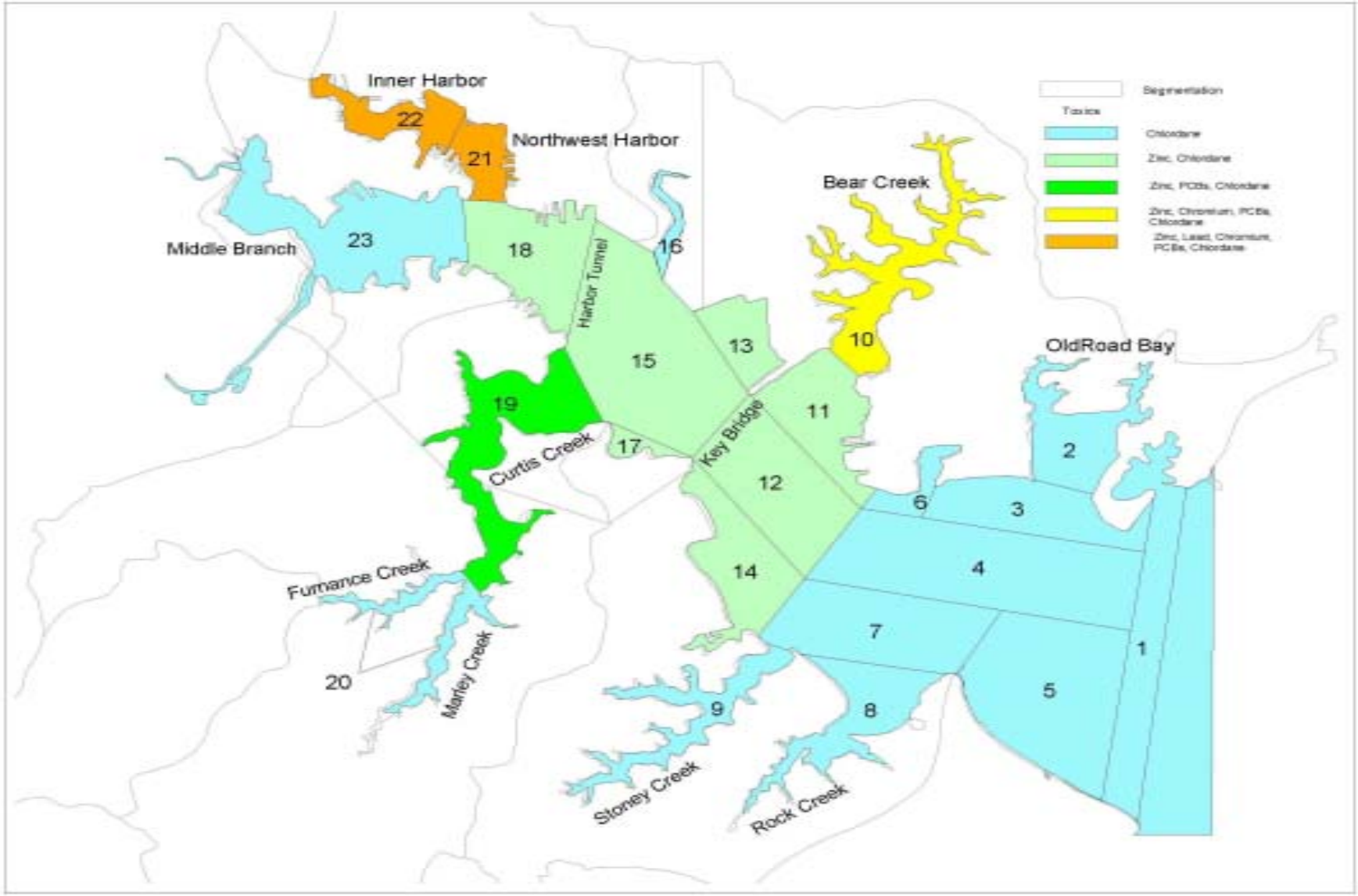
# Baltimore Harbor Toxic TMDLs

- The Harbor TMDL is based on impairments reported on the 1996 and 1998 303(d) lists.
- The TMDLs will determine the limits on loads of polluting substances that will allow the water to meet the water quality standards.
- These limits will be reflected in municipal and industrial permits and in the application of non-point source controls.
- A series of models will determine loads coming off the land (watershed model) and how the pollutants are diluted or lost and relate to water quality (water quality model which has several parts).

# Water Quality Impairments in Baltimore Harbor

- **Toxic contamination in sediment**
  - **Chlordane and PCBs**
  - **Toxic metals (Chromium, lead, zinc)**
- **Fish consumption advisories**
  - **Bottom feeding fish (catfish, carp, eels) contain unacceptable levels of chlordane**
- Eutrophication- excess nutrients; low dissolved oxygen
  - Nutrients: Nitrogen and Phosphorus
- Fecal coliform

# Baltimore Harbor Toxic Impairment



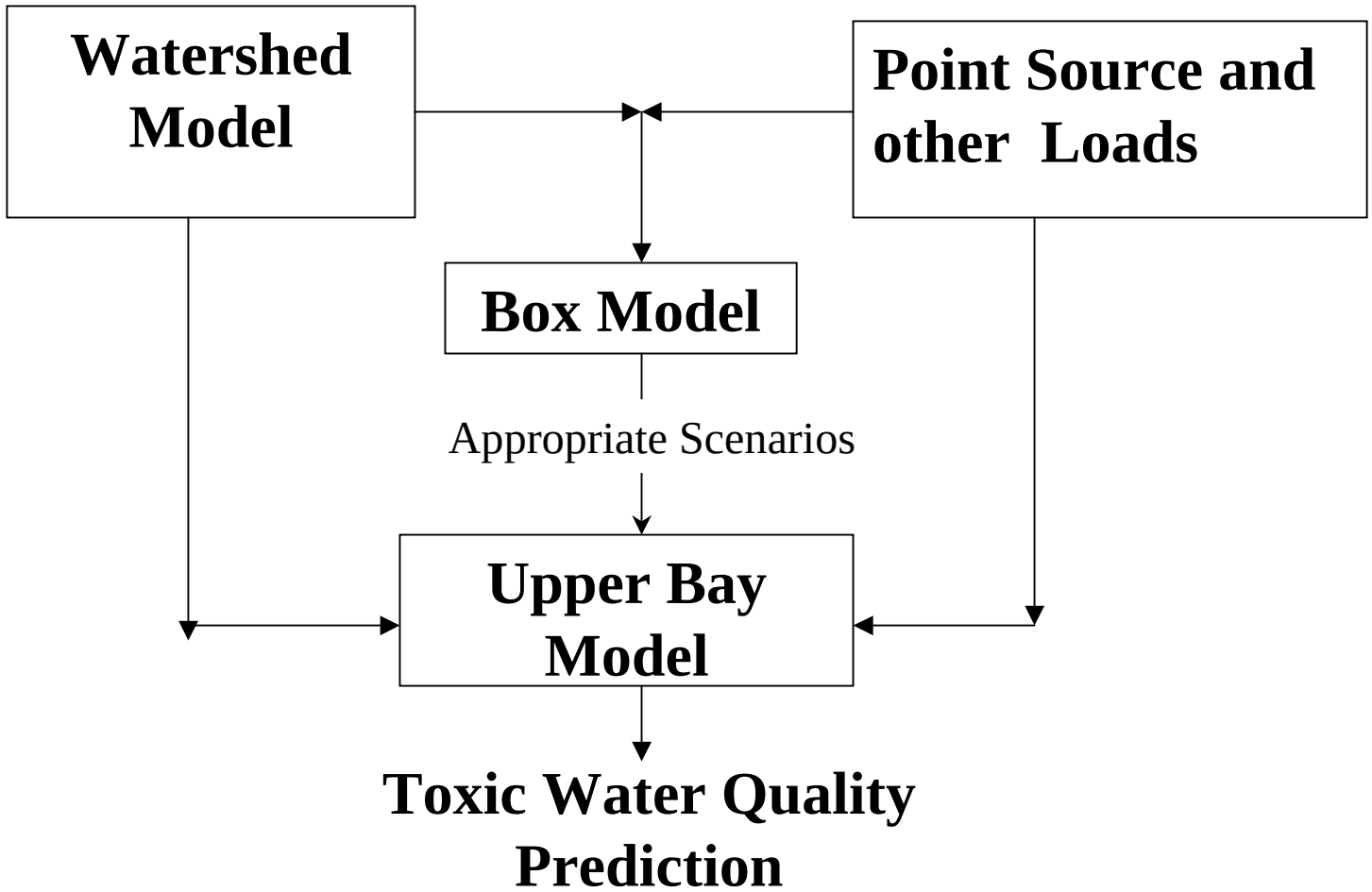
# Toxic Data Sources and Assessment

- Baltimore Harbor Sediment Mapping Study
  - Chemistry (Metals, PCBs, PAHs) – 80 Stations
  - Toxicity Study – 25 Stations
  - Benthic Community – 40 stations
- Sediment Fluxes – Baltimore City
- NPDES data for point sources and Baltimore City nonpoint sources
- Whole Effluent Toxicity (WET) program data
- Fish Tissue
- CHARM – Comprehensive Harbor Assessment and Regional Model Study (1996-2000)
- PBGM – Patapsco/Back/Gunpowder/Middle River Chemical Contaminant Survey (2001-2002)

# Harbor Toxics Modeling Program

- **Estimate Nonpoint Source Loads -**
  - **Model the watershed - estimate loads from the land to the water**
  - Provide inputs to the Harbor Models
  - Uses a Storm Water Management Model (SWMM)
- **Simulate Fates of Toxics in Baltimore Harbor – Harbor Models**
  - **Management/Screen (Box Model) - UMCES**
    - Hydrodynamics (water transport) and Sediment Transport
    - Toxic (Dissolved/Particulate)
    - Food Web
  - **Detailed Assessment (Upper Bay Model) - VIMS**
    - Models entire upper Bay to include exchange between the Harbor and the Bay
    - Hydrodynamics (water transport) and Sediment Transport
    - Toxic (Dissolve/Particulate)

# Harbor Toxics Modeling Framework



# Harbor Toxic Watershed Modeling

**Estimate Nonpoint Source Loads**

# Toxics – Watershed Model

## Storm Water Management Model (SWMM)

- Nearly Completed : Chromium, lead, zinc
  - Internal/External Review Completed
- UNDER DEVELOPMENT : PCB
- Primarily Urban Runoff Model (wet weather flow)
- Recent EPA Updates by Urban Watershed Management Branch
- Multiple Buildup/Washoff Functions

# SWMM – Model Calibration for Metals

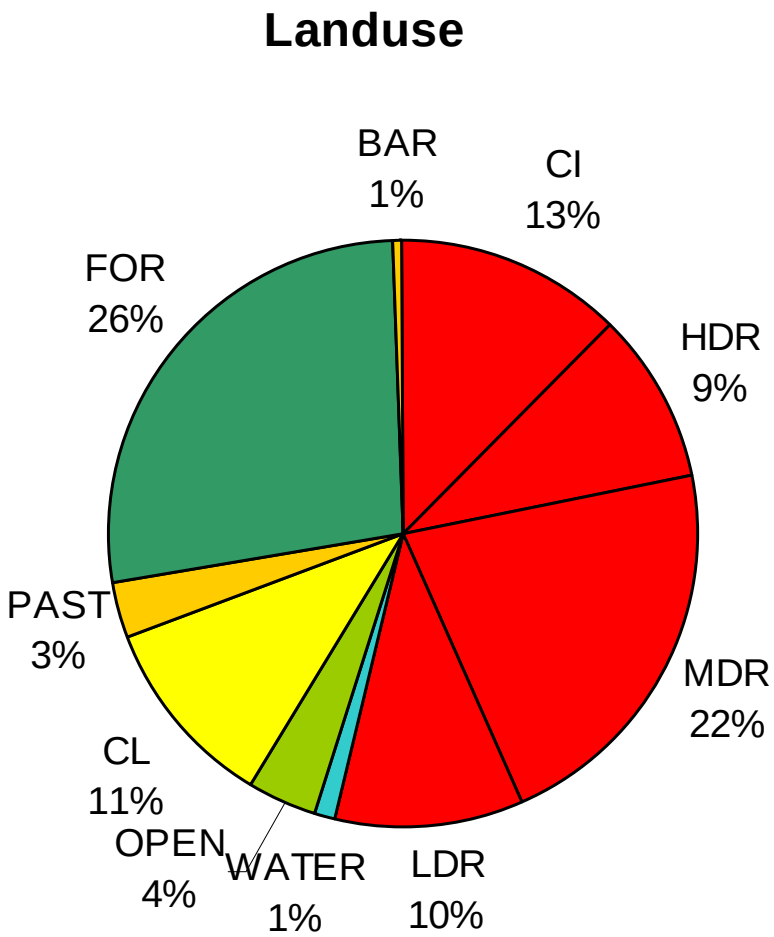
- Focus on landuses which are predominantly industrial, commercial and residential (54%).

For–Forest CL-Crop Land

Bar–Barren Pas-Pasture

CI, HDR, MDR, LDR-Industrial, Commercial and Residential

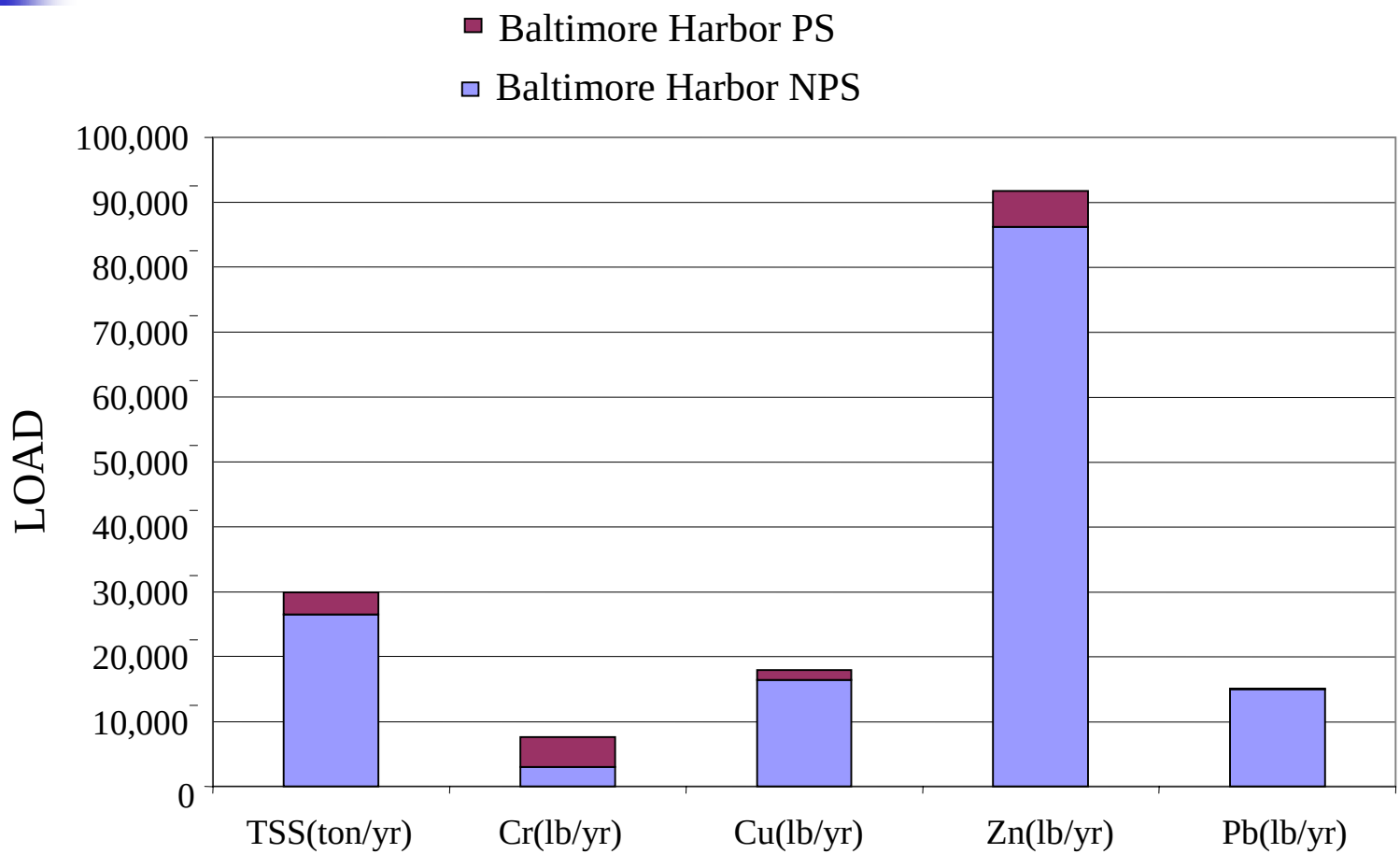
Open-open land Water-water



# SWMM Landuse Loading Summary

| Landuse | TSS (tons/yr) | Cr (lb/yr) | Cu (lb/yr) | Zn (lb/yr) | Pb (lb/yr) |
|---|---|---|---|---|---|
| **CI** | 26% | 65% | 25% | 50% | 43% |
| **HDR** | 13% | 8% | 23% | 14% | 16% |
| **MDR** | 20% | 15% | 32% | 20% | 20% |
| **LDR** | 8% | 7% | 6% | 8% | 6% |
| **Sum Urban** | **66%** | **94%** | **86%** | **92%** | **86%** |
| **OTHER** | 34% | 6% | 14% | 8% | 14% |

# Baltimore Harbor Toxics Watershed for Total Metals - Summary



# Harbor Toxic Modeling

**Simulate Fates of Toxics in Baltimore Harbor**

# Harbor Toxic Modeling Framework
## UMCES – Box Model

- A useful screening tool to quickly test the relative consequences of different loading scenarios under a variety of forcing conditions.
- Boundary condition: Horizontally uniform Harbor boundary conditions for temperature, salinity and suspended sediments derived from observed data.
- Model Status
  - Hydrodynamic/Sediment Transport - Linking Nonpoint Source and Point Source Loads
  - Toxic Box/Foodweb - Final Stage

# Harbor Toxic Modeling Framework
# UMCES – Hydrodynamic/Sediment

- Data : Time varying sea level at the Harbor mouth and time-varying winds to predict the temporal evolution of currents, sea-surface elevation, and water properties within the Harbor for 4 observed months.
  - May 1995
  - October/November 1999 – CHARM 1
  - March/April 2000 – CHARM 2
  - July/August 2000 – CHARM 3
- Grid size :
  - Horizontal – 360m * 360m
  - Vertical – 6 layers (Sigma Coordinate)

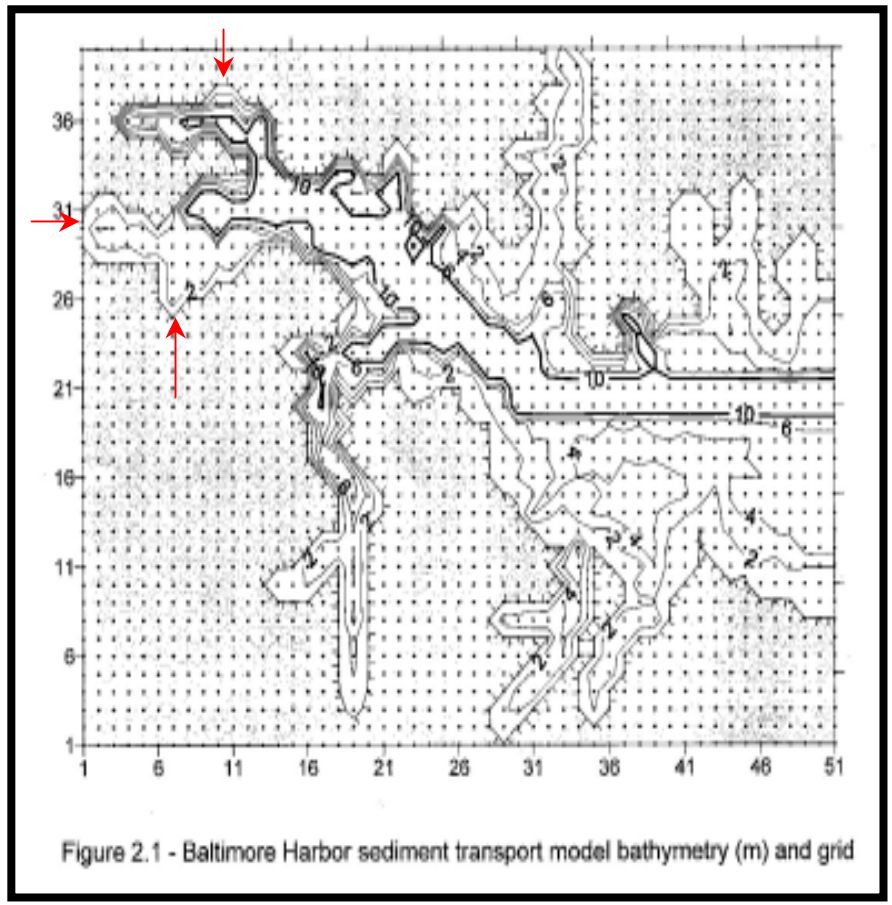
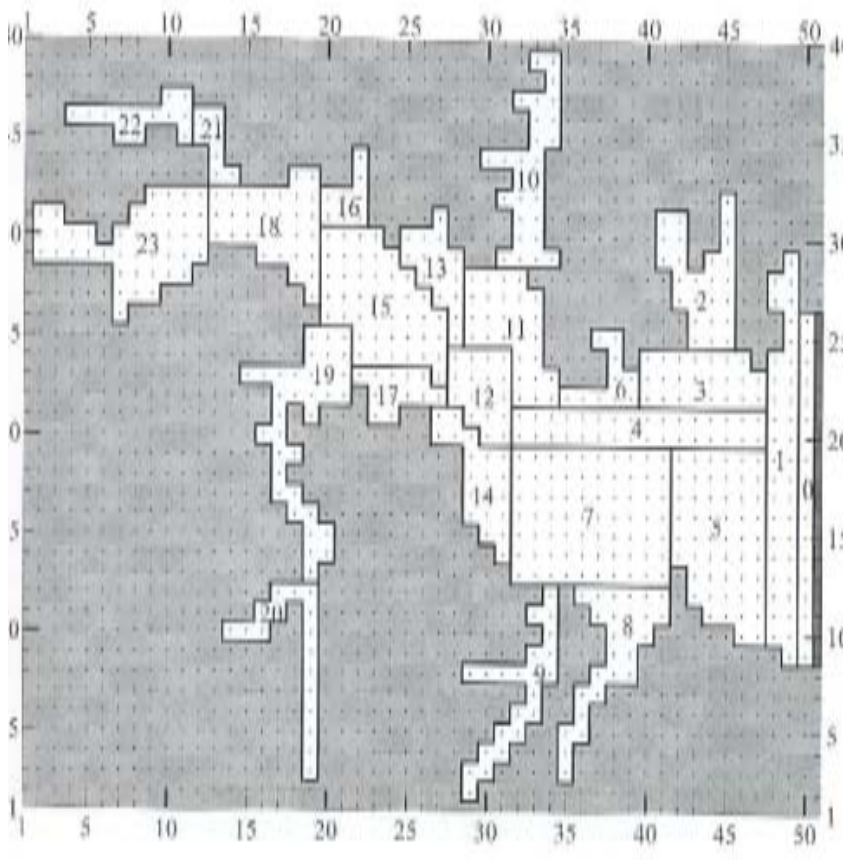


Figure 2.1 - Baltimore Harbor sediment transport model bathymetry (m) and grid

# Harbor Toxic Modeling Framework
# UMCES – Toxic Box Model

- Spatially-explicit 24-box model
- Assumes the water column is a completely well mixed system.
- Simulates the spatial distribution and transformations of HOCs, Organic Carbon, Metals and biomass within the Baltimore Harbor.
- Run Time : Hours



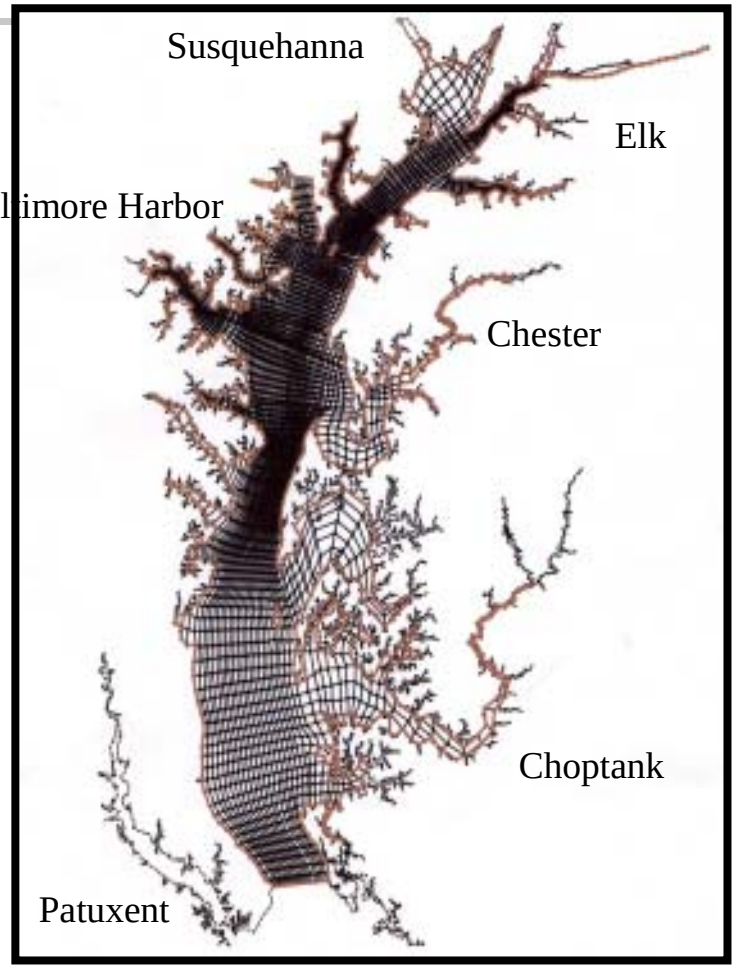
# Harbor Toxic Modeling Framework
# VIMS – Upper Bay Model

- A real time simulation
  - Covers entire Upper Chesapeake Bay Hydrology with more refined boundary conditions for Baltimore Harbor
  - One-to-one linkage between hydrodynamic and toxic components.

- Model Status
  - Hydrodynamic/Sediment Transport - Final Stage
    - 1995, 1996 Calibration completed
    - Working on year 2000 and 2001
  - ToxiWasp (simulating fate of toxic) – In Progress

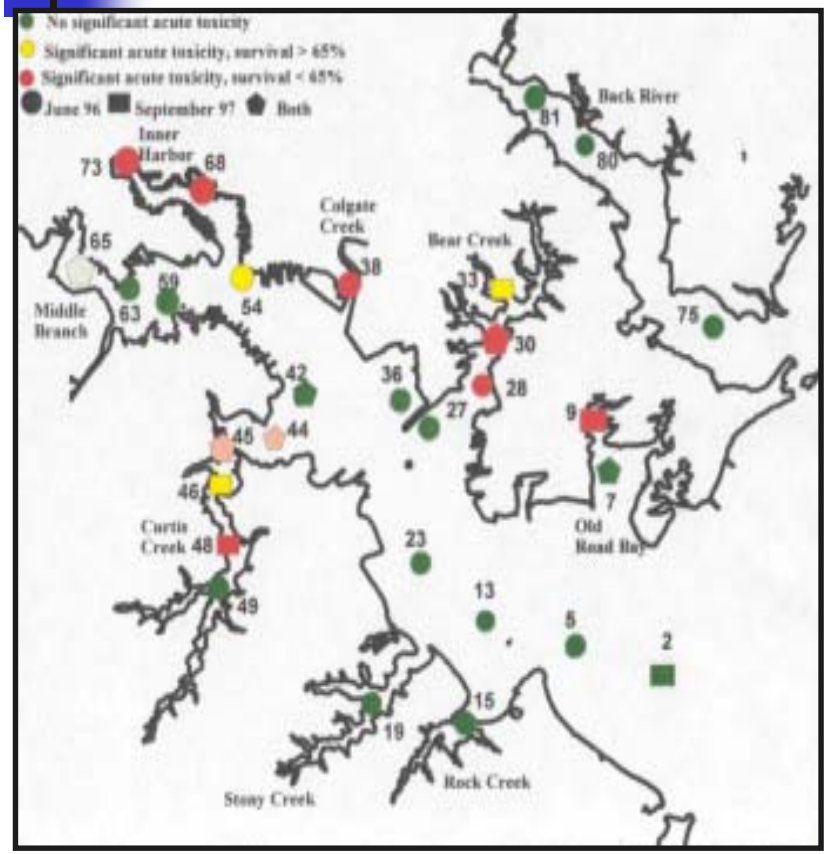
# Harbor Toxic Modeling Framework
## VIMS – Hydrodynamic/Sediment transport

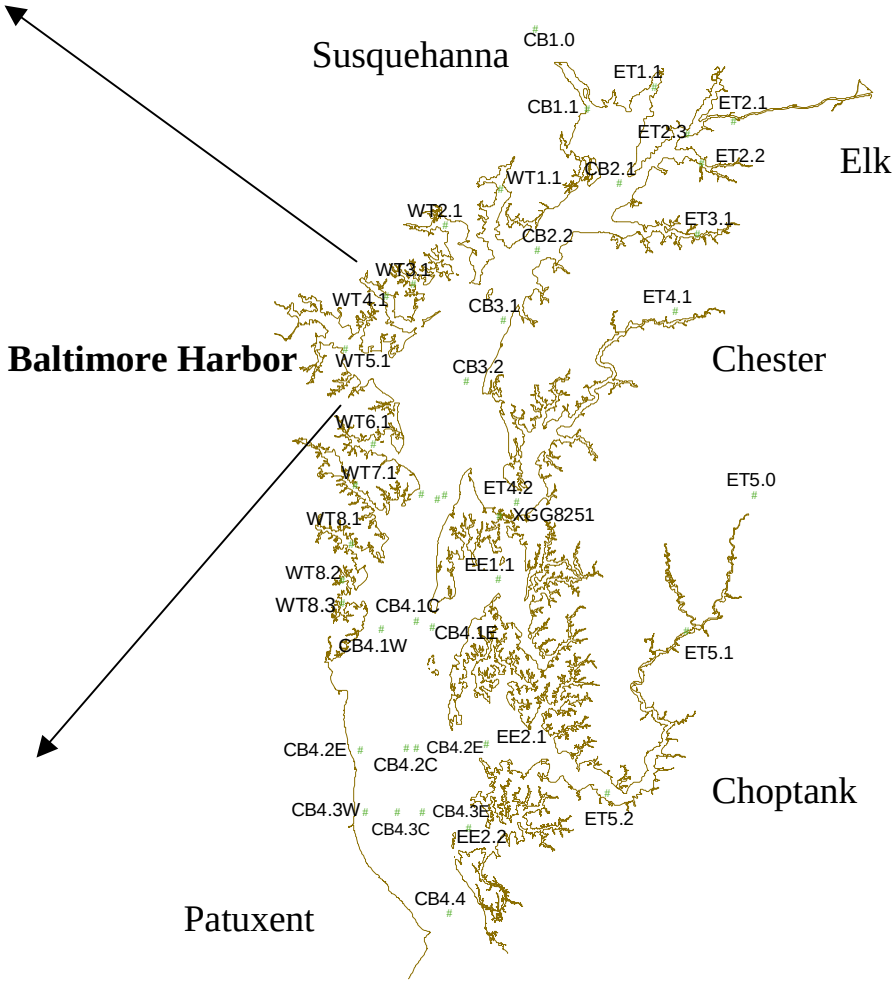
- Open Boundary Conditions
  - The long-term tidal data from Solomon Island at Patuxent River
  - Salinity and temperature at CB4.4
- River Boundary Conditions
  - Susquehanna River
  - C & D canal
  - Chester River
  - Choptank River
- The grid resolution
  - 0.5 km longitudinally
  - 0.25 km laterally
- The preliminary results show that the model is capable of reproducing turbidity maximum and simulating major temporal and spatial features.



# Harbor Toxic Modeling Framework

## VIMS –Hydrodynamic/Sediment Model Calibration stations



# Future Actions

## August 2002

- Complete CHARM point source sampling – finalize data report
- Finalize watershed model report
- Continue working on calibrating hydrodynamic and toxic components
- Work with Stakeholders

## December 2002

- Finalize hydrodynamic calibration
- Preliminary Toxic Model calibration
- Sensitivity test of Nonpoint source/Point source load reduction using UMCES Box Model.
- Work with Stakeholders

# Eutrophication Modeling in Baltimore Harbor

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# Water Quality Impairments in Baltimore Harbor

- Toxic contamination in sediment
  - Chlordane and PCBs
  - Toxic metals (Chromium, lead, zinc)
- Fish consumption advisories
  - Bottom feeding fish (Catfish, carp, eels) contain unacceptable levels of chlordane
- **Eutrophication - Excess Nutrients; Low Dissolved Oxygen**
  - **Nutrients; Nitrogen and Phosphorus**
- **Fecal coliform**

# Existing Data for Nutrients

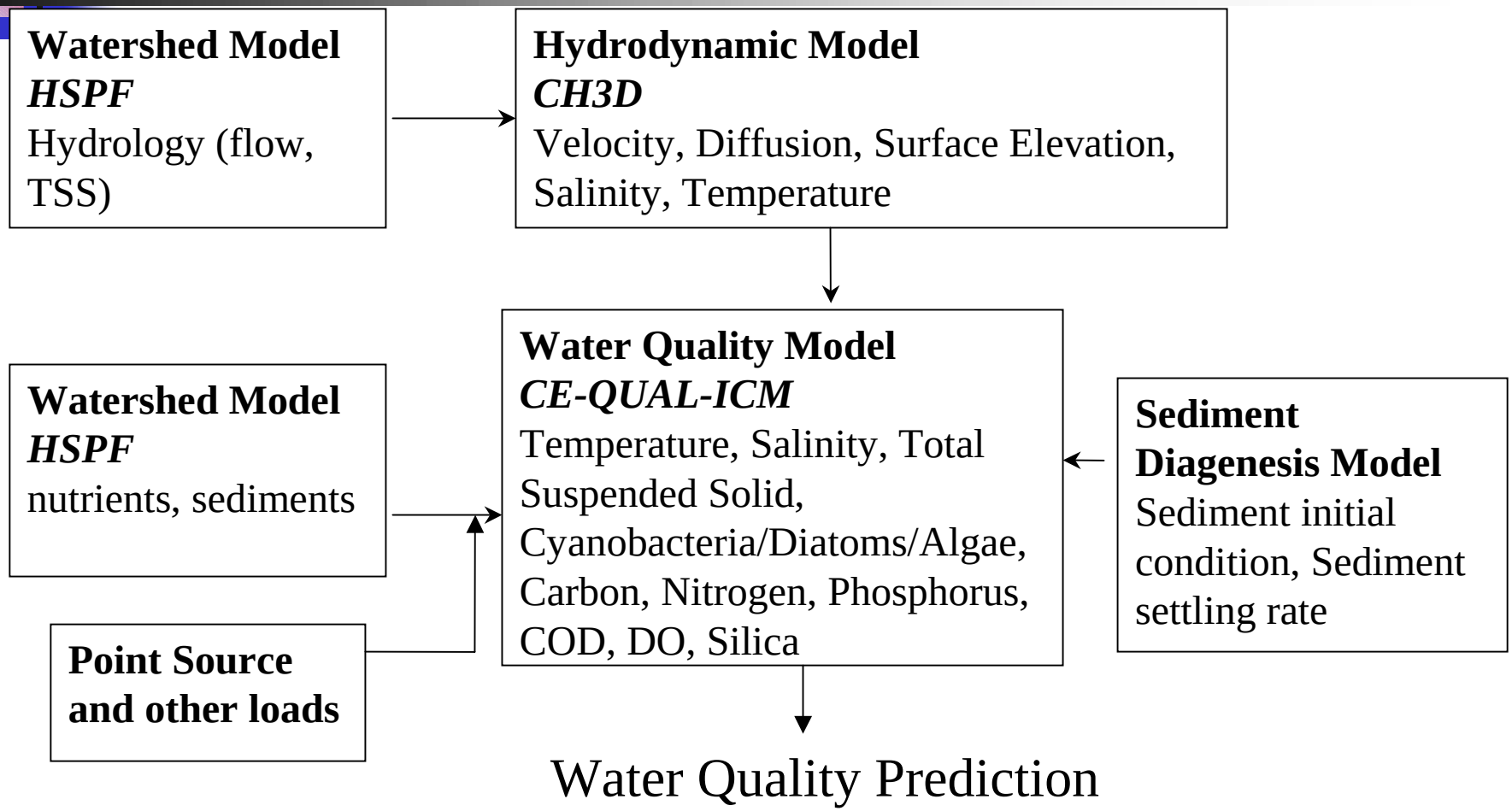
- NPDES discharge permits
- Water column
  - MDE 94-95 sampling
  - Baltimore City Department of Public Works 96-97
- Benthic flux - rate of movement of nutrients from sediment to water
  - Upper Bay
    - Chesapeake Bay Program 82~
    - University of Maryland 94, 95, 97

# Harbor Eutrophication Modeling Program

- **Estimate Nonpoint Source Loads - Watershed Modeling**
  - Hydrologic Simulation Program: Fortran (HSPF)

- **Simulate Water Quality in Baltimore Harbor – Harbor Modeling**
  - A 3-D **Hydrodynamic** Model - Curvilinear Hydrodynamic 3-Dimension (CH3D)
  - A 3-D Comprehensive **Water Quality** Model - CE-QUAL-ICM
  - A **Sediment** Diagenesis Model

# Harbor Eutrophication Modeling Framework



# Harbor Eutrophication Watershed Modeling

**Estimate Nonpoint Source Loads**

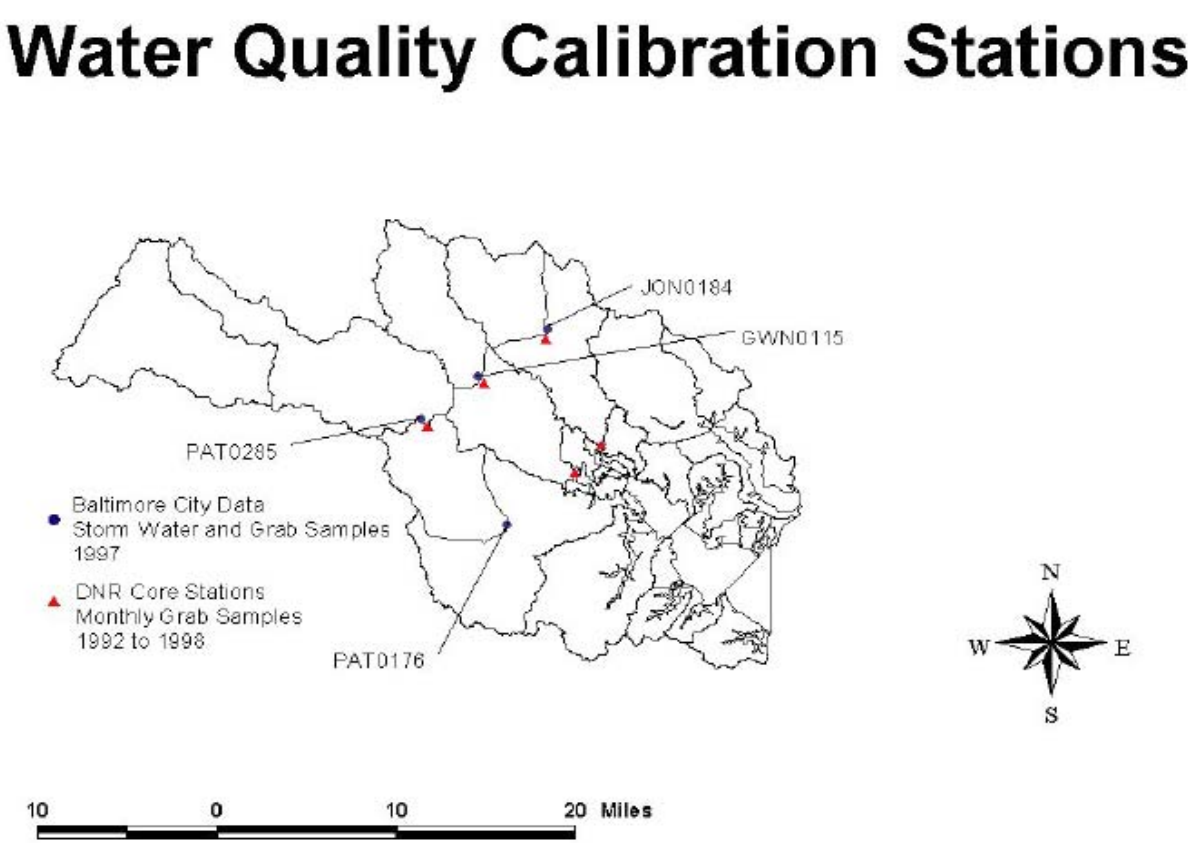
# Eutrophication – Watershed Model

HSPF – Hydrologic Simulation Program: Fortran

- HSPF is used to estimate nutrient, flow, and TSS loading
- The model incorporates;
  - Seasonality
  - Meteorological Data
  - Landuse
  - Agriculture Information
  - Soil types
  - Monitoring Data

# HSPF – Model Calibration

- Focus on predominant land uses
- Calibrate EOS loads to literature values
- Calibrate urban loads to Event Mean Concentrations (EMCs)
- Time series overlay



# HSPF Landuse Loading Summary

| Loading Rates (lbs/ac/yr) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area | Sediment | | | TN | | | TP | | |
| | | min | avg | max | min | avg | max | min | avg | max |
| **Urban** | **175,977** | **19** | **157** | **394** | **5.31** | **6.62** | **7.71** | **0.55** | **0.68** | **0.89** |
| MDE(93-97) | | | 134 | | | 6.90 | | | 0.53 | |
| CBP(93-97) | | | 382 | | | 13.81 | | | 2.14 | |
| **Forest** | **83,521** | **48** | **110** | **333** | **0.86** | **1.91** | **3.40** | **0.09** | **0.12** | **0.20** |
| MDE(93-97) | | | 131 | | | 2.64 | | | 0.22 | |
| CBP(93-97) | | | 685 | | | 2.50 | | | 0.14 | |
| **Crop** | **30,765** | **148** | **234** | **366** | **6.59** | **6.69** | **6.80** | **0.21** | **0.59** | **0.82** |
| MDE(93-97) | | | 366 | | | 15.03 | | | 0.48 | |
| CBP(93-97) | | | 2,383 | | | 21.21 | | | 1.42 | |
| **Pasture** | **11,382** | **148** | **277** | **491** | **3.74** | **5.34** | **6.80** | **0.12** | **0.39** | **0.66** |
| MDE(93-97) | | | 223 | | | 8.01 | | | 0.19 | |
| CBP(93-97) | | | 1,087 | | | 11.84 | | | 1.91 | |

**Red : Literature values**

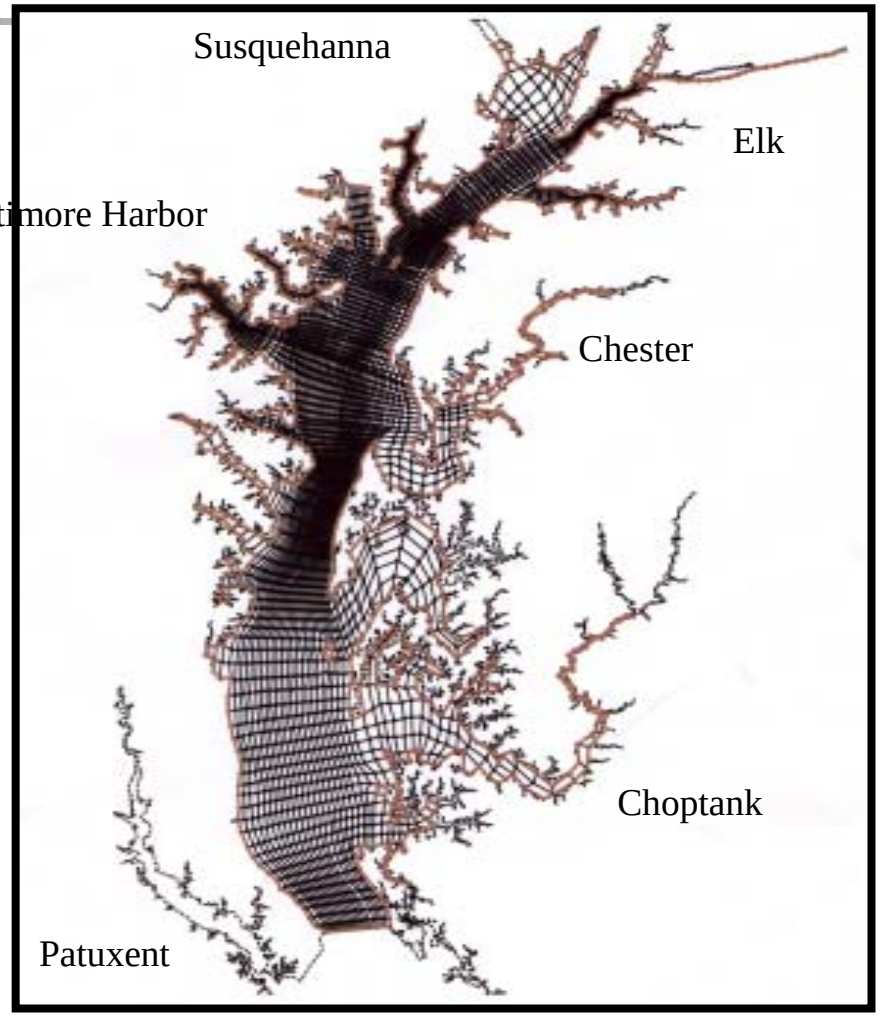
# Harbor Eutophication Modeling

**Simulate Water Quality in Baltimore Harbor**

# Harbor Eutrophication Modeling
## Hydrodynamic Model

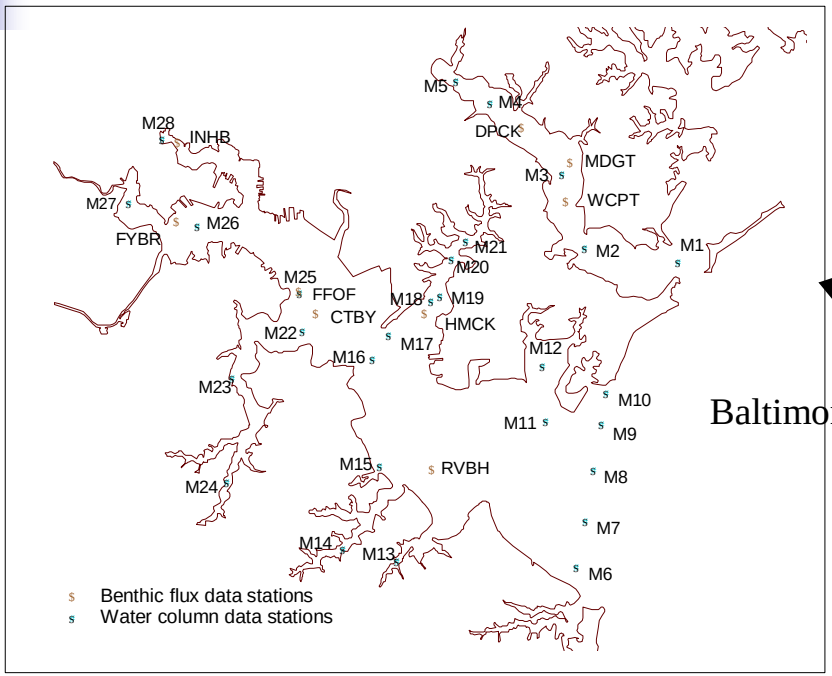
- CH3D for Upper Chesapeake Bay - Same Hydrodynamic model as for the toxic Upper Bay Model, but without intratidal sediment transport model

- Calibration - Final Stage

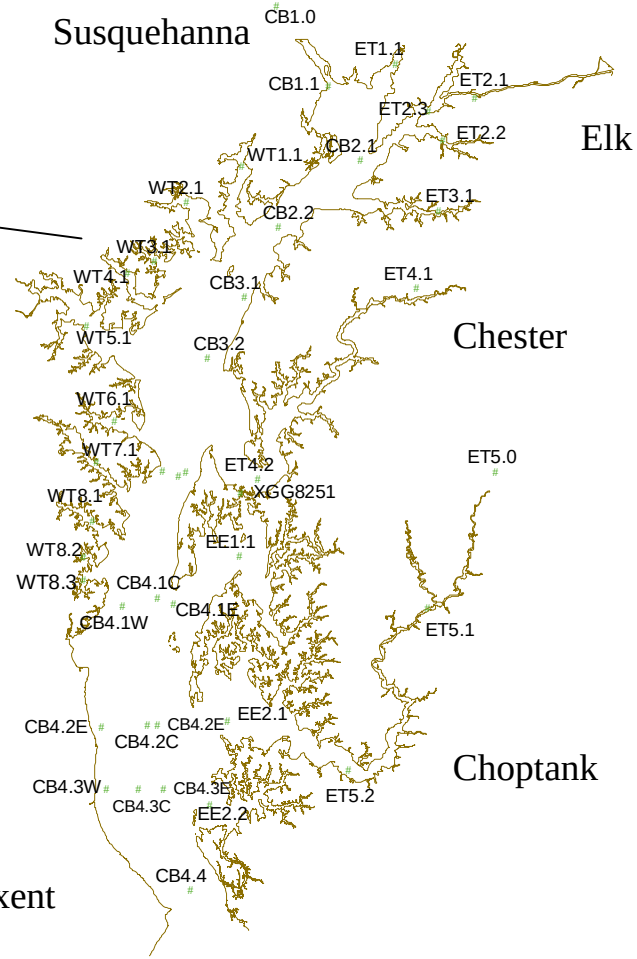


# Harbor Eutrophication Modeling

## CH3D Model Calibration stations




Baltimore Harbor



# Current Eutrophication Model Status

- Watershed (HSPF) – Calibration Final (Internal/External Review Completed)
- Hydrodynamic Model – Calibration Final (Internal Review completed)
- Water Quality Model – In Progress

# Future Actions

## August 2002

- Finalize Watershed and Hydrodynamic Models
- Preliminary Water Quality Model Calibration
- Sensitivity Test of Nonpoint Source/Point Source Load Reduction
- Work with Stakeholders

## December 2002

- Finalize Water Quality Model Calibration
- Preliminary Scenario strategy
- Work with Stakeholders